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ROYAL BOTANIC GARDENS, KEW

L—SOURCES OF VEGETABLE WAX. F. N. Howes.

In spite of the wide-spread occurrence of vegetable waxes throughout the vegetable kingdom, very few are of commercial importance or are regarded as being of potential commercial value. The most important of those known to commerce are carnauba wax, candelilla wax, esparto or "fibre" wax, and "Japan wax". The last mentioned, although commonly referred to as "wax", is not a true wax as will be explained later.

Vegetable waxes are utilised for a variety of manufacturing purposes but principally in the preparation of polishes of various kinds. Other more limited uses to which they are put are in the manufacture of candles of certain types, wax varnishes, cable coverings and electrical insulators, sealing and dental wax, phonograph records, carbon papers, photographic plates and certain pharmaceutical and other preparations for which beeswax is commonly employed. Although the use of vegetable waxes in polishes and dressings for such articles as saddlery or harness may have diminished in recent years, increasing applications for them have been found in other directions, notably in the manufacture of motorcar polishes and in the waxed cartons now so commonly used for food-stuffs. The value of most vegetable waxes for industrial purposes lies largely in their relatively high melting point and in the fact that the addition of even small quantities to other softer animal or mineral waxes may cause a marked rise in the melting point of the resulting mixture.

In the countries of origin certain of the vegetable waxes have been in use, chiefly as illuminants, from remote periods. Some are still commonly employed by native peoples for this purpose in the form of torches or candles, in spite of the now extended use of cheap mineral waxes. In candle-making they are generally mixed with a proportion of tallow or other fat by the natives in order to render them less brittle or to prevent too rapid burning. Only small quantities of vegetable wax are now used in commercial candle-making. Nevertheless candles of vegetable wax are manufactured and marketed for special purposes. They are favoured for church use on account of the agreeable odour they give out when burning.

The term wax is applied somewhat indiscriminately to a variety of plant products that resemble beeswax in general appearance and

physical properties. In some instances, as in the case of Japan wax (*Rhus*) and berry wax (*Myrica*) they consist of glycerides and should be considered chemically as fats rather than waxes, or as mixtures of fat and wax. True waxes are devoid of glycerine or glycerides and are a combination of fatty acids with certain monatomic alcohols. Among plant products waxes may be regarded as intermediate between the fats and the resins, and are perhaps more closely allied to the resins in chemical and physical properties than they are to the fats.

The true waxes are to be found among plants chiefly as a thin surface covering on some particular organ or organs. Almost any part of the plant, with the exception perhaps of subterranean organs, may bear the wax coating. In some plants it may be limited to a certain organ or organs, in others it may occur more or less over the whole surface of the plant. Leaves and fruits are perhaps the parts most commonly affected. The characteristic whitish coating or bloom of numerous fruits, particularly certain varieties of grapes and plums, is due to wax which generally appears as the fruit approaches ripeness or maturity. A more conspicuous development of wax on the fruit is to be seen in the wax gourd, *Benincasa hispida* Cogn. Wax on the leaf surface is readily noticeable in numerous everyday plants such as the carnation, certain conifers, the cabbage and other species of *Brassica*. Other well known genera in which marked wax development on the leaves may occur are *Eucalyptus* (young leaves), *Buxus*, and *Mesembryanthemum*. In these, as in so many other plants, the wax is present in too small a quantity for collection to be attempted for economic purposes. The best known instances where wax occurs in sufficient quantity on the leaf surface to warrant collection are perhaps afforded by the palms, particularly the carnauba wax palm, *Copernicia cerifera* Mart. and the wax banana of the East Indies. Instances of wax development on the stem are well exemplified in certain species of *Euphorbia*, especially *E. cerifera* Alc., the source of candelilla wax, and in the wax palm of the Andes, *Ceroxylon andicola* H. & B. In many of the taller growing grasses and most varieties of sugar cane, wax is very noticeable on the stems and leaf-sheaths, particularly in the vicinity of the nodes. Wax development on the stem is also conspicuous in some varieties of the castor oil plant (*Ricinus*) and on the stems of certain species of *Rubus*, notably *R. biflorus* Buchan. and *R. Giraldianus* Focke, natives of the Himalayas and China respectively, and sometimes cultivated as ornamental plants. In these two species of *Rubus* the wax coating is sufficiently thick to render the stems vividly white in appearance as if white-washed, noticeable particularly in the winter months when the leaves have fallen. In addition to its occurrence on leaves, stems and fruits, wax may also occur in appreciable quantity on the floral organs of some species.

Although wax appears usually on the outer surface, it does sometimes occur and remain in the inner tissue. In *Balanophora*, for

instance, wax is secreted chiefly in the stem parenchyma. In *Ficus* and *Brosimum* wax or wax-like substances occur in the milky sap or latex in admixture with other substances. In cotton (*Gossypium*) wax is present on the seed fibres or lint in extremely small quantities. Although the percentage of wax is so small, commonly ranging from ·2–·6% (6) it is nevertheless an important factor in certain manufacturing processes with cotton, such as spinning, wetting, dyeing, scouring, etc. and has a direct bearing on the feel of cotton as estimated by the grader.

The method of formation of wax within the plant cell—whether it originates from the protoplasm or the cell membrane— does not appear to be thoroughly understood. It is possible that in view of the wide differences in relationship among plants producing wax, the product may not be always secreted in the same manner. Apart from seed-bearing plants many of the lower plants such as certain fungi, which naturally have different metabolic processes, are known to form wax. The primary function of the wax appears to lie in rendering the organ which it covers impermeable to water, as is the case with numerous fruits on which water or rain may fall without wetting. It no doubt assists also in the prevention of loss of moisture by the plant, exemplified in the wax coated leaves of many species inhabiting desert or semi-desert regions and in strand formations.

Wax occurring on the surface of plant organs may be present in the form of a smooth homogeneous glaze, or as a powder consisting usually of small loosely arranged rodlets, or as small scales or crusts. Frequently the structure is definitely crystalline and in some cases where the wax scales are relatively large they bear on their under surface the impression of the part of the leaf from which they became dislodged.

In the account of wax yielding plants that follows, only those genera or species are dealt with that are known to yield wax in fair quantity or have actually been utilised by man in some part of the world for the production of wax for his own needs.

Montan wax, which is derived from a certain type of coal, and Peat wax may be classed as waxes of vegetable origin. However, as they are more generally regarded as mineral waxes they have not been included in the discussion that follows.

Balanophora.

The *Balanophoraceae* are an interesting family of root parasites that occur chiefly in tropical and subtropical mountainous regions in Asia and South America. The family includes a number of species that exhibit profuse wax development, particularly in the genus *Balanophora* itself.

All the species of the genus do not produce wax, the best known in this respect being some that occur in the mountainous districts of Java, notably *B. elongata* Bl., *B. globosa* Jungh. and *B. Ungeriana* Val. The first mentioned of these is reputed (10) to produce the most

wax and occurs at altitudes between 2,000 and 3,000 metres. The wax occurs in the parenchyma of the rhizome and is present in such quantity that when dried and ignited, the rhizomes burn brightly. They have been used by natives in Java as sources of illumination, candles or small torches being made from them. In order to prepare the torches, specimens of which are in the Kew Museum, the plants are washed, pounded up and heated in a receptacle. Thin strips of bamboo about 15 inches long and 1/8 inch in diameter are then dipped into the molten viscid mass. On being removed the portion that has been immersed remains coated with a layer of waxy material which sets quite hard on cooling. These torches were found to burn slowly and steadily with quite a bright light but a good deal of smoke. The wax itself can be easily separated from the rest of the plant tissue when in the molten state. A sample in the Kew Museum, which is bright yellow in colour, closely resembles beeswax in general appearance and texture. The wax is said to possess a high melting point and to contain a certain amount of fat or resin. It has been stated that *Balanophora* rhizomes are an article of trade among natives in Java but this is believed to be erroneous. Although the percentage of wax is high, it is doubtful whether the plants occur anywhere in sufficient quantity for the wax to become an article of commercial importance (10).

Brosimum.

A so-called wax, cow tree wax, has been described (30) as being obtained from *Brosimum Galactodendron* D. Don, the cow tree of the South American forests. This tree is of large dimensions reaching a height of 100 feet with the trunk usually unbranched for the first 60 or 70 feet and 6 to 8 feet in diameter at the base. It is particularly prevalent in the forests of Venezuela. By making incisions in the trunk a latex or sap is obtained which somewhat resembles cow's milk and is used as an article of food by the inhabitants in some areas. On standing a scum or cream forms which thickens in consistency and becomes yellow in colour. When this sap or milk is boiled, a yellowish white resinous material separates out. It is of soft consistency, somewhat transparent when fresh, and can be kneaded with the hands. Its superficial resemblance to beeswax may have earned for it the name of cow tree wax. Actually the material consists mostly of resin (16). This substance has been used for torches by the inhabitants of the areas where the tree occurs and has also been considered for chewing gum manufacture.

Ceroxylon (Ceroxylon or Palm Wax).

The wax palm of the Andes (*Ceroxylon andicola* H. & B.,) which bears a thick coating of a waxy substance on the bole, occurs at altitudes between 2,000 and 3,000 metres. It has a limited distribution, occurring only in western tropical South America, but

is very abundant in some of the areas where it occurs. Attention was first directed to it by the well known travellers Humboldt and Bonpland who found it extending almost to the lower limit of perpetual snow on the mountains lying between the Magdalena and Cauca rivers in Colombia. It is of interest among palms on account of its great size, specimens as high as 57 metres having been recorded, also for its occurrence at much higher altitudes than is usual in the *Palmeae*. It is no doubt the tallest of the palms. In matured specimens the bole is usually about a foot in diameter at the base and is somewhat swollen towards the centre, contracting again as it approaches the crown. The large pinnate leaves attain a length of 20-25 feet and on decaying and falling leave closely set scars encircling the trunk.

The palm is said to present a handsome sight when in fruit as the large hanging racemes of brilliant scarlet fruits form a striking contrast with the white marble-like trunk (5).

Wax is secreted on the bole in thick hard crusts, white or whitish in colour. It occurs also in small quantity as a thin powdery layer on the under surface of the leaflets, but this is not utilised. The great height of the palms renders collection of the wax, which has to be scraped from the bole with a blunt instrument, somewhat difficult. In early times the palms were always felled, but in more recent years encouragement has been given to methods of procuring the wax from the palm without felling and thereby effecting its destruction. The occurrence of moss or lichen on the trunk may impede collection. The wax is present on the bole in quite considerable quantity, that is as compared with most wax yielding plants, and may be $\frac{1}{2}$ cm. thick (30). The yield of a single palm is about 25 lbs. and to fell and scrape two palms is said to constitute a day's work for one man (24). After collection the wax or wax dust is melted and clarified, or boiling with water may be resorted to. It is an article of commerce among the inhabitants in parts of Colombia. Before being made into candles by the inhabitants, it is usually mixed with about a third its weight of tallow. This is said to render the product less inflammable and more suitable for candle-making.

Specimens of the crude wax in the Kew Museum are in the powdered and in the solid form. The first mentioned is of a pale straw colour, almost white, and the latter yellowish tinged with green. Both possess a pleasant odour. The crude wax contains a good deal of impurity, no doubt on account of the manner in which it has to be scraped from the stem and the fact that earthen moulds may have been used for the molten wax. Purification, however, can easily be effected, a simple method being to heat the crude wax in canvas or calico bags weighted down under water, when the wax rises to the surface (15).

Crude ceroxylon wax as scraped from the palm trunk contains a large proportion of resinous material mixed with it. It is this

resinous matter that may account for the relatively high melting point recorded for Ceroxylon wax by some observers. The pure wax, which is present to the extent of about 30%, has been described as golden brown, brittle but not very hard, with a melting point in the neighbourhood of 65° C., which is lower than that for carnauba and candelilla wax. At one time it was thought that the product might well be used as an alternative for carnauba wax for a number of purposes, providing supplies were forthcoming in sufficient quantity and in a reasonable state of purity. However, extensive tests of crude ceroxylon wax by a large firm of polish manufacturers during the last few months led them to the conclusion that it was of little use as a substitute for carnauba wax in polish-making.

In regions where the *Ceroxylon* wax palm occurs other parts of the plant besides the wax are made use of by the inhabitants. The tall straight trunks are very durable and afford a useful material in the construction of dwellings, boats, water pipes, etc. The leaves may be used in roofing and the crown of the palm bears a fibre resembling gommuti fibre or piassaba (24).

It would appear that a distinct or varietal form of this palm may be present in some parts of Colombia. Dawe (5) in an account of a journey through the western portion of Colombia records the occurrence of a dwarfed form of the wax palm on the Cordillera Central which" has the concentric rings around the bole closer and more irregular, the fronds more outspreading, and the wax coating on the underside of the leaves browner in colour." He states that it " more usually affects the higher altitudes " and is of more economic importance from the point of view of wax production.

Cocos.

Wax has been shown to be present in the sediment which collects on the bottoms of tanks in which coconut oil (*C. nucifera* Linn.) has been stored. Tanchico (28) has extracted and investigated the wax from this sediment or oily residue in the Philippines. He states ".....the purified coconut oil residue does not yield glycerin as a decomposition product and is, therefore, not a glyceride. This residue would appear to be a wax containing the myricyl ester of cerotic acid." He found the purified product to have a melting point of 88° to 90°C. The crude coconut oil residue, after removal of oil, dust and other impurities, was used in combination with other materials in making trial lots of " floor wax ", " furniture polish " and " leather polish " which were found to be satisfactory. Little appears to be known regarding the yield of this waxy residue from coconut oil and it is said to vary considerably. According to Tanchico " at one mill it was surmised that 500 tons of coconut oil stored for about three months would perhaps yield 40 kilos of sediment. At others where the oil was stored longer the estimates ran much higher."

Copernicia (Carnauba Wax).

Carnauba wax, which is commercially the most extensively used of the true waxes of vegetable origin, is obtained from the leaves of *Copernicia cerifera* Mart., a palm occurring in north eastern Brazil. It is commonly known as the Brazilian wax palm, whilst colloquial names for it in Brazil are " carnauba ", " carnahuba ", " carnahyba ", " carnanahyba " and " caranda." It occurs in the states of Ceara, Rio Grande do Norte, Pernambuco, Piauhy, Maranhão, Matto Grosso, Bahia and also in Venezuela (29). In Ceara it is particularly prevalent and this state is the centre of the wax industry. It frequently occurs in groves flanking the rivers. The palm is remarkable in its propensity for resisting drought and in thriving under conditions of extreme dryness. In most of the areas where it occurs there is normally a prolonged dry season about half the year, when no rain falls. Nevertheless growth and the production of new leaves continues throughout this season. Periods of absolute drought for two or three years have occurred in the Carnauba region and it has been observed (30) that during such times, when all other vegetation is completely parched and dried up, the carnauba palm remains green and may be in flower. It is resistant to fire, and fire does not visibly affect its vitality except in the young stages. During the rainy season some areas where the palm occurs may be subjected to flooding for long periods when the basal portions of the palm become completely submerged. This does not appear seriously to effect the palm in any way. Nevertheless, it is considered to flourish most in areas where it is not subjected to such flooding.

The height of the palm varies from 20 to 40 feet and the circumference of the bole from 12 to 18 inches. The deeply lobed, flabelliform leaves are densely arranged and the crown is more or less spherical. The youngest leaves in the centre of the crown are yellowish or yellowish green in colour due to the presence of a thin powdery coating of wax. This wax occurs on both surfaces but is more strongly developed on the upper surface of the young leaf and causes it to possess a peculiar although pleasant smell at this stage of its development. As the young leaf develops the ash-like waxy coating adheres less tenaciously and may eventually be dislodged by even a puff of wind. When the leaves have wholly expanded little or no wax remains. On this account only the younger leaves are collected for the preparation of the wax.

For wax production the young leaves are collected during the dry season and usually the palms are subjected to two cuttings per month. On an average 8 young leaves are removed from a palm at each cutting or approximately 100 in a season. They are severed by means of a suitable implement—a knife or a sickle—attached to a long pole or stick. The inhabitants show great skill in the cutting of the leaves. In removing the young leaves the youngest inner leaves in the centre are left undisturbed. These furnish the harvest in the

next cutting. The fact that young leaves are cut continuously from the palm during the six rainless months of the year testifies to its vitality. During the rainy months of the year cutting does not take place and normal leaf development occurs.

After cutting, the young leaves are laid out in rows in the open to wilt and dry for several days. This has the effect of loosening the wax coating. They are then conveyed to a convenient centre for removal of the wax, or this may be effected on the spot. The wax is removed by beating each leaf in turn with a stick. Before beating, the leaves are split several times with a knife which facilitates removal of the wax. Cloth or matting may be used to collect the wax as it is beaten from the leaf. The operation may be carried out in the open or more usually in a closed shed or room which helps to minimise loss as the wax particles are light and easily lost by wind. Even when special buildings are used for beating, ventilation has to be provided and any draught carries out a stream of fine wax particles (4). There is always therefore a certain element of loss. This naturally varies in accordance with weather conditions and the amount of care exercised. It is thought by those competent to judge that this loss may sometimes amount to as much as 25% (4). The process of beating is generally carried out by women. After being collected the wax particles or powder are heated in a receptacle with a small quantity of water and when molten run into moulds. On cooling the wax is inclined to break into pieces of irregular size owing to its brittle nature.

The yield of wax obtained from any given number of leaves is very variable as the amount of wax formed is dependent to some extent upon locality and also to a larger degree upon pluviometric conditions. When the rainfall in the wet season preceding cutting is lower than usual a lower wax yield results. It is stated (24) that in very dry years the yield may be only one tenth of that obtained when conditions are favourable. According to figures quoted by Dahlgren (4) for a grove in the district of Fortaleza in Ceara for the years 1921, 1923 and 1931, the average wax production was 6·9 gms. per leaf or 143·7 leaves worked per kilogram of wax obtained. This writer states " The highest yield during the years in question was that of a third cutting in 1923 which gave 10·9 gms. per leaf. The lowest yield was that from the expanded leaves of the first cutting in 1921 which yielded an average of only 4·3 gms. per leaf."

Attention was first directed to the wax of the carnauba palm early last century but export of the commodity did not commence until considerably later. In 1846 about 23 tons were exported from the port of Ceara : and by 1860 export had risen to 60 tons (25). At the present time several thousand tons are annually exported from Ceara. The wax is marketed under several grades which are valued according to colour, purity and oil content. Sand or earthy matter is the chief impurity. The better grades are yellow in colour, while

the inferior are various shades of grey or black. The following are the grades arranged in order of quality—that are commonly imported into this country for manufacturing purposes—" yellow flor ", " prime yellow ", " medium ", " cauhype ", " fatty grey ","chalky". " Cauhype " is a grade intermediate in quality between the recognised yellow and grey types. Other inferior grades in the country of origin are those known as " gordurosa " and " arenosa ". In polish manufacture different grades are utilised for different types of polish. The wax is brittle, hard and amorphous, with a melting point of 84-86°C. It possesses a peculiar but agreeable odour.

In the early days of the importation of carnauba wax into European countries its use in candle-making was disfavoured owing to the difficulty in bleaching. This however was subsequently overcome. Candles made with it are stated to burn well and to give off a pleasant odour, which accounts for their popularity in church use. Carnauba wax is chiefly of value as a hardening substance for all manner of waxy compositions, a small percentage being often sufficient to raise the melting point considerably. In polishes it causes a high lustre and is used in a great variety of polishing materials, particularly polishes and creams for footwear, leather and furniture. Its use in the manufacture of phonograph and gramophone records is due to its possessing the right degree of hardness without the crystalline structure that is a hindrance with many materials. It is used in the manufacture of carbon papers for typewriting, for certain pharmaceutical preparations, and for various other purposes.

Serious attempts at the cultivation of the Carnauba palm on a large or commercial scale in other countries do not appear to have been made. This may be because of (*1*) the large amount of labour necessary in the collection of the wax, (*2*) the lack of information regarding the rate of growth of the palm and the age at which leaf cutting could be commenced and (*3*) the fact that there are large areas in Brazil in which the palm occurs freely and which have not yet been exploited to any extent for wax. The palm has been introduced to various parts of the tropics for experimental cultivation, chiefly in botanical gardens. It has been grown in British Guiana, the East Indies, East Africa, Ceylon and Malaya. It is stated to grow well at Singapore (2).

Some twenty years ago a Hamburg seed-merchant sent circulars all over the tropics recommending the cultivation of this palm, stating that its requirements as regards soil and climate were not exacting and that it would probably be suitable for interplanting with rubber, cacao, coffee, etc., which is however extremely improbable (10).

In those parts of Brazil where the palm occurs it is put to various minor uses in addition to the production of wax. The leaves yield a fibre which is used by the natives in making cordage, rope, hammocks, fishing nets, etc. In preparing this fibre the leaves are not retted in any way but are simply cut into strips and scutched on

boards set with nails or even fish bones. It was estimated at one time (25) that about a third of all the cordage material used in Ceara was made from the Carnauba palm. The fibre was exported to European countries and used for stuffing mattresses and furniture and in making hats, baskets, brushes, etc. (24). It has been suggested that a use might be found—either for fibre or for paper-making—for the leaves that are collected for wax production after the wax has been removed. Normally these leaves are burned. The mature leaves being light and waterproof are commonly used as a thatching material. Like many other palms the boles are utilised in the construction of dwellings, being hard and fairly durable. When fully matured the boles yield a " wood " which is hard, a bright yellowish red in colour with black streaks and capable of taking a good polish. It has been imported to European countries for the manufacture of walking sticks. The roots are regarded by the natives as possessing medicinal properties and have even appeared in Britain as a substitute for sarsaparilla but, as would be expected, without success. The roasted seeds have been used as a substitute for coffee or fed to cattle and poultry. Like other palms the Carnauba palm can be tapped and syrup or toddy made from the sap. A starchy material or " sago " may also be obtained from the upper part of the stem.

Euphorbia (Candelilla Wax).

The most important wax-yielding species of this large genus is *Euphorbia cerifera* Alc., the source of the candelilla wax of commerce which is derived from Mexico.

The plant is a perennial and consists of a woody root-stock from which arise several cylindrical stems, up to seventy or more, which are somewhat knotted or jointed and vary in height from 2 to 5 feet and $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter. The flowers are yellow and seed is formed profusely. The leaves are small and inconspicuous and soon fall from the stems. They are only present at certain periods, notably while the stems are young. The entire surface of the mature stems is covered with the wax coating, which is very apparent to the sight and touch, and which is easily removed with the blade of a knife or even the thumb-nail. It imparts to the whole plant a greyish-green or ashen appearance. Wax is stated (19) to be present under the epidermis in additon to the external superficial layer or covering.

The shrub occurs freely in many parts of Mexico, particularly in the north and the total area which it covers is very extensive. It occurs in the following States—Puebla, Hidalgo, San Luis Potosi, Tamaulipas, Nuevo Leon, Coahuila, Durango and Chihuahua (19). It also exists in lower California and in the semi-arid highland regions of South West Texas (8). Exploitation for wax has so far been chiefly in San Luis Potosi and Coahuila. In fact it is estimated (8) that approximately 80% of the total amount of candelilla wax reaching the world's markets is from the factories in the vincity of Nueva Laredo and Piedras Negras, from plants growing mostly in the pro-

vince of Coahuila. From these factories the wax is railed to the port of Tampico for shipment to various parts of the world.

The plant prefers the highlands to low lying regions and occurs for the most part where rainfall is low and where desert-like conditions prevail. In some of the mountainous districts where the plant is exploited roads are few and far between and the shrubs, as they are cut, are tied in bundles and placed on the backs of horses and mules for conveyance to the nearest collecting centre, from which they proceed by vehicular transport to the wax recovery plant. In gathering, the stems are either pulled or cut at ground level with a knife. If pulled, portions of the root accompanied by earthy matter may remain attached to the stems. The yield of fresh plants per acre in some areas is from one to two tons. Naturally yield varies according to the prevalence of the plant and its state of growth. After cutting, from two to five years elapse before the plant completely re-establishes itself.

With regard to the extraction of the wax, two methods are in use (*1*) the old method by means of boiling water and (*2*) the more recent method of solvent extraction. The last mentioned is more efficient in every way, for nearly double the percentage of wax is recovered and operating costs are lower. It is the method adopted in the more progressive and up-to-date factories. Many of these are owned or controlled by American interests.

The following description of the old method accompanied by a few remarks on the solvent extraction process are given by Govier (8). " Wooden or lead lined vats are used, capable of treating about 500 lbs. in a batch. A solution of sulphuric acid is used in the vat with a strength of approximately 10% which is heated either with live steam or direct fire. The weeds are tipped into a net of iron chains which is placed in the bottom of the vat before it is filled. The temperature of the contents is raised to boiling point, and the candelilla is kept submerged about 6 inches below the surface of the boiling solution for about 10 minutes, when the molten wax leaves the plant and collects on the surface of the solution. It is then skimmed off and transferred to lead lined or galvanised tanks. The exhausted weeds are lifted out of the vat with chains and burned under the boilers. The solution in the vats is changed about twice weekly.

The crude wax is refined by re-melting, and is kept at boiling temperature to remove the water that has been carried over with the skimmed wax. It is later drawn off from the refining tanks into pans, where it is permitted to settle overnight. Dirt, twigs and other foreign matter settle to the bottom of the pan, and when the cakes are removed from these pans the impurities at the bottom of the wax are scraped off and returned for re-settling. The clean cakes, still retaining considerable moisture, are placed in another refining tank and heated until the moisture is reduced to less than 1% when the colour of the wax is usually a light brown. It is finally drawn off into

pans, allowed to set, then turned out and sacked for market. Alternatively the wax can be bleached by exposure to the sun in thin sheets. By the crude method of recovery described above, it is possible to obtain a yield of from only one to one and a half per cent. of refined wax from the plant."....." For the extraction method the gathered plants are usually allowed to dry in the sun for two weeks before being prepared for extraction. The candelilla is pulverised and placed in solvent tanks containing benzol (carbon tetrachloride can be used) and the wax is dissolved. The solvent wax solution passes through a filtering medium and the clear solution is subjected to distillation, thus recovering the solvent for re-use. This cycle is continuously repeated and if the equipment is efficient, the loss of solvent during the process is very small. The wax residue remaining after the distillation of the solvent can be refined if necessary before cooling and breaking up for packing."

The percentage of wax obtained per unit of the fresh plant varies with plants from different districts and it has been stated (14) that in well watered areas the yield of wax is less than in the more arid districts. It is also claimed (14) that the character of the wax varies somewhat according to the age of the plants and the time of year when they are cut.

There are other wax yielding plants in Mexico of somewhat similar appearance to *Euphorbia cerifera*. One of these is *Pedilanthus pavonis* Boiss. which may occur in the same areas and be known by the same common name. The stems are taller and thicker than those of the true " candelilla " plant and the wax is produced only in negligible amount. It has been suggested that the cutting of such plants along with those of true " candelilla " for wax production may also be responsible for the differences that exist in the properties of different commercial samples of the wax which are so evident. Standley (27) regards *Euphorbia cerifera* Alc. and *E. antisyphilitica* Lucc. as synonymous, but others (19) do not share this view and believe that two quite distinct plants are involved.

True candelilla wax is grey or greyish black in colour, coarse grained, opaque and somewhat brittle. The purified wax is generally brown or reddish in colour, opaque to translucent, with a pleasant odour not unlike beeswax. It is not so hard or brittle as carnauba wax. The melting point of the crude wax is between 80 and 92°C and of the purified wax between 67 and 82°C. (30). It is commonly exported only partly purified in the form of large broken lumps in sacks each containing from 70 to 80 kilograms. Unlike carnauba wax recognised commercial grades do not appear or exist. The wax has not been known for so very long and first appeared at an exhibition at San Antonio in 1907 (30). By 1910 it had appeared on European markets and in the following years production increased and candelilla wax soon became a well known commodity among the users of vegetable waxes, being utilised in very much the same manner as carnauba wax.

The industrial uses of candelilla wax are many. On account of the high lustre it imparts it is specially favoured for polishes and creams for foot- and leather-ware. It also enters into the composition of various other polishes, particularly floor and furniture polish. Mixed with other materials, rubber, gutta percha, etc. it is employed in electric insulating materials and varnishes. Other uses for the wax are found in the water-proofing of fabrics, in dental moulding compositions, paint removers, paper sizes, sealing waxes, metal lacquers and lithographic colours (19).

Many other succulent species of *Euphorbia* exhibit wax development on the stems in a greater or less degree, but as a rule it is not marked and the wax is present only in small quantity. Two species that have attracted attention on account of the wax present are *Euphorbia xylophylloides* Brongn. and *E. stenoclada* Baill., both of which occur in Madagascar. These species have not, however, been exploited commercially. It was found (9) that after the plants had been cut into small pieces and dried the wax could be easily beaten off. The product so obtained was placed in boiling water when the molten wax could be skimmmed from the surface. An alternative method tried was to place the plant direct into boiling water after collecting. This method, however, gave a smaller yield of wax but the delay caused in drying was obviated. With it a yield of just over one pound of wax was obtained from a single somewhat undersized plant of *E. xylophylloides*. It was considered that larger plants growing at lower altitudes would yield double the quantity of wax. The yield from *E. stenoclada* was found to be a little less than that of *E. xylophylloides*.

Ficus (Godang Wax).

Wax or wax-like substances have been obtained from the latex of certain species of *Ficus* (30), the best known being the godang " wax " of Java. This wax, or so-called wax, is yielded by *Ficus variegata* Bl., a large forest tree with a wide distribution over south-east Asia and common in parts of Java. It is stated that in middle and west Java godang " wax " is prepared by the natives by heating the latex to which water has been added, over a fire. The grey to brown coloured " wax " eventually rises to the surface and is removed. It can be bleached and has been sold in the bazaars for use in batik work and for candles. A similiar " wax " is stated to have been prepared in Sumatra and Ceylon (30).

According to some observers this " wax " is little known in Java and is probably seldom or never prepared now or used in batik work. It has been shown that the so-called wax in the crude state consists mostly of resin and that it is hardly justifiable to term it wax (10).

Langsdorffia.

This is another parasitic genus of the *Balanophoraceae* which, like *Balanophora*, secretes wax freely.

The solitary species of the genus, *Langsdorffia hypogaea* Mart., has a wide distribution in Central and Southern America and has been recorded from Mexico to Southern Brazil, having thus a range of about 52° latitude. It occurs chiefly at the higher elevations and is reputed to be common in some of the mountainous areas of Colombia.

The wax occurs within the tissues of the plant and not as a superficial layer or coating. It is present to the extent that if one end of a stem or rhizome be lighted, it burns as freely as a wax taper. In referring to the species, Sir Joseph Hooker (11) stated "This species yields so large a quantity of wax that candles are made of it in New Grenada. The secretion is contained entirely in the cellular tissue, where it appears as a large opaque mass in every utricle. Mr. Purdie informs me that near Bogota the stems are collected and sold in the markets under the name of *Siejos*, and used as candles on saints' days. On the Tolima range it is called "Belacha", and "Melousita" on the mountains around Bogota where its soft receptacle is eaten when ripe and considered stimulating and refreshing. It is remarkable that *Langsdorffia*, the only monostylous American genus, should resemble *Balanophora* in the abundance of its waxy secretion; whilst *Rhopalocnemis*, the only distylous Asiatic species, resembles the other American *Helosideae* in the absence of wax."

Linum (Flax Wax).

The outer epidermal layer of the stem of the flax plant, *Linum usitatissimum* Linn., contains wax in appreciable quantity (30). This wax, which may be obtained as a by-product in the preparation of flax, has been prepared and used for manufacturing purposes.

A detailed account of experimental preparation of this wax and the possibilities of its use commercially has been given by Gibson (7). This writer points out that the wax is contained in the fine dust or "pouce" which accumulates during the various combing and drawing processes to which the raw flax fibre is subjected on entering the spinning mill. This dust, usually regarded as a troublesome waste material, may contain up to about 10% of wax. It may be removed by solvent extraction processes, although various difficulties have to be faced.

Flax wax extracted from material grown in various parts of the world and under various conditions did not exhibit any marked differences in properties. The following is a description of it—"Flax wax corresponds closest to beeswax, from which it is distinguished by a slightly lower saponification value, a higher iodine value, and a distinctly higher melting point. The wax is of a dark green or brown colour, according to the state of the chlorophyll present, which is apparently mainly affected by the process of retting, and the ripeness of the flax straw when pulled. It resembles beeswax closely in character but is slightly harder and rather

more brittle. It is not, however, a brittle wax like carnauba wax. Owing to its higher melting point and greater hardness it is superior to beeswax in its capacity to give an extremely high polish. The polished film of flax wax is stated by Honneyman to be more durable than that of carnauba wax on account of its greater plasticity. For these reasons flax wax would be a very valuable constituent of polishing preparations unless a pale colour was essential" (7).

Musa (Banana Wax).

Certain species and varieties of *Musa*, both wild and cultivated, form wax to a noticeable extent on the fruits, petioles, or under surfaces of the leaves. In one of the well known cultivated cooking varieties of banana in Malaya (pisang abu) the ripe fruits, although actually yellow, are ashen in appearance owing to a well developed waxy coating. A similiar variety (abu kehel) showing profuse wax development on the fruits exists in Ceylon and is also popular for cooking.

Throughout Java and Malaya wild bananas occur (forms of *Musa zebrina* van Houtte and *M. malaccensis* Ridl.) in which the undersurfaces of the leaves are quite white owing to the presence of wax (12). In parts of Java, this wax has been collected and utilised by the natives, but in Malaya this does not appear to be the case. Possibly the wax layer on the leaves is more profuse in Javanese forms than in Malayan. It is quite probable environmental conditions may partly determine the extent of wax formation for it is stated (10) that in *M. zebrina* in Java wax development is greater at the higher altitudes than at the lower levels. Where this species occurs it is often very prevalent, particularly on the margins of forest, in jungle clearings and along river banks. It reaches a height of 10-20 feet or more in favoured situations and bears several leaves about 6 feet in length and 2 feet across. In order to obtain the wax the leaves are cut and the white mealy undercoating, consisting of wax, scraped off by hand by means of blunt knives and wooden implements. This is then placed in boiling water and the molten wax subsequently removed from the surface. It is stated (10) that another practice is to place the scrapings in one of the leaf sheaths of the plant which is kept at an inclined position over a fire. As the wax melts it runs down and drips off the end of the leaf sheath, where it is collected in some receptacle or other, often an empty coconut shell. The wax may then be filtered through some fibrous material in order to remove impurities.

It would appear that this so-called " banana wax " was better known and more generally used in Java in the past than it is at present, being a bazaar commodity in some areas and used in batik work. It is described (30) as being hard, more or less transparent, and white, creamy yellow or light green in colour, according to the amount of chlorophyll that has become mixed with it. It breaks with a coarsely crystalline fracture and is easily powdered. Usually a good

deal of fragmentary plant material, and sometimes insect remains, are present. The melting point is high (79-81°C.) and no doubt various uses would be found for the wax if production on a larger scale were practicable.

It is stated (10) that the yield of wax in Java is approximately $\frac{1}{2}$ Kgm. per 100 leaves or 5 gms. per leaf. Recent figures for carnauba wax in Brazil indicate 6·9 gms. per leaf as an average yield. In view of the considerably greater surface of the banana leaf as compared with that of the young leaf of the carnauba palm it is apparent that the wax yield from the banana is relatively considerably less. Furthermore the process of extraction is a good deal more laborious. According to Heyne (10) one man does not collect in a day more than 1/8 kati (1 kati = $1\frac{1}{3}$ lb. approx.) of wax for which two loads (man loads) of leaves have to be worked.

Myrica (Myrtle " Wax ").

Many species of *Myrica* bear a waxy coating or encrustation on the fruits, which is collected and utilised as wax in various parts of the world. The material is not a true wax as has already been pointed out, for it consists largely of glycerides and is more correctly regarded as a vegetable fat. Countries where the so-called wax myrtles occur freely and are exploited for " wax " are South Africa, North America, Mexico and Colombia.

The " wax " obtained from the different species of *Myrica* in these countries is very similar in appearance and general properties. The same method of extracting appears to be employed throughout. The fruits or " berries " are collected by hand from the plants, or, in some instances may be shaken from the bushes on to canvas or cloth spread beneath them. Then are then placed in boiling water or more usually in sacks or bags, preferably loosely woven, which are kept immersed in boiling water for a time, when the " wax " rises to the surface and is collected and moulded into cakes of the desired shape. The " wax " appears as the fruits approach maturity and hardens to a crust consisting of numerous minute scales. It may also occur on the leaf surface but in insufficient quantity for collection. The colour is grey or more often pale or dark green, owing to the presence of chlorophyll and colouring matter or other impurity from the pulp of the fruit. When bleached or chemically refined it is white. The purity of the " wax " is dependent in some degree upon the age of the fruits when collected and the care exercised in extraction. In some species, when the fruits or " berries " are unduly old, the dried pulp is inclined to break into small fragments which became contaminated with the " wax ". Prolonged boiling tends to extract colouring matter from the pulpy material which darkens the " wax ". The chief use of *Myrica* " waxes " is for candle-making in the countries of production and as an adulterant of beeswax. Their relatively low melting point, generally between 40°C. and 45°C. no doubt precludes their more extended use for industrial purposes. Occasionally parcels

of myrtle " wax " are handled by wax dealers in this country. Candles made from it from the Cape and from Colombia were found to burn slowly with little smoke but a rather poor light and to give off a somewhat balsamic odour.

In South Africa several species of *Myrica* bear a waxy encrustation on the fruits and are capable of yielding " wax " in a greater or less degree. These species are for the most part evergreen shrubs occurring in sandy maritime areas in the south western districts where they are sometimes very prevalent. *Myrica cordifolia* Linn. is probably the best known species and has the largest fruits bearing the most " wax ". It is common in and around the Cape Peninsula and elsewhere in the Western Cape Province where " berry wax " is a well known commodity. It is stated (23) " It is extensively used by the Dutch population of the Western Province in conjunction with paraffin wax and soap as a home-made floor-polish, but manufacturers of floor-polishes maintain that it lacks certain essential properties for use in manufactured polishes. It makes an excellent material for use in oil baths in chemical laboratories, being preferable to paraffin wax, as it can be heated to a much higher temperature without emitting unpleasant vapours. It is stated that the Hottentots use it as an article of food." The " wax " attracted attention as early as 1777 (21) and has frequently been the subject of investigation with a view to commercial utilisation. Small quantities have in the past been exported to Europe and the United States. A soap of good quality and agreeable odour can be made from it, but the usual costs of production of the wax do not allow of its extended use in this direction. It is stated one man can collect from 1½ to 2 muid sacks of the " berries " in a day and that one muid sack yields from 11 to 14 pounds of " wax ". At the Cape the months from May to November are regarded as the best for collecting. The plant occurs under a variety of soil conditions but attains to its best development and yields most prolifically in maritime situations where it is often an important species in the " fixing " of sand-dunes on account of its spreading branches and root-system. The shrub does not come into bearing until about 4 years of age and is inclined to fruit sporadically from one season to another in some areas (21).

In North America the " wax " obtained from the fruits of *Myrica cerifera* Linn., the wax myrtle, became an article of commerce in the early days of colonization there and was exported. This shrub or small tree is native to the south-eastern United States and occurs abundantly in some areas, particularly in moist, sandy localities in Carolina, Virginia and Pennsylvania. It also occurs in the West Indies. The early settlers in North America made free use of the " wax " in candle-making. The fruits, which are about 1/8 inch in diameter, are at first green, then blackish and eventually white when the waxy encrustation has formed. They may persist on the branches throughout the winter and 4 lbs. of

" berries " are said to yield 1 lb. of " wax " (20). Another North American species with profuse " wax " development is *Myrica carolinensis* Mill. the " small waxberry " or bayberry. This shrub is smaller than the closely related *M. cerifera* and has been regarded by some as a northerly form of it. The fruit is somewhat larger than that of *M. cerifera* and is believed to be still used as a source of "wax" in some areas. The plant has a wide range extending from Nova Scotia and New Brunswick to Florida.

In Mexico at least two species of *Myrica* are exploited for " wax ". These are *M. mexicana* Willd. (syn. *M. xalapensis* H.B.K.) and *M. Pringlei* Greenm. The first mentioned, a shrub or small tree reaching a height of about 20 feet, is the best known. It is widely distributed, occurring roughly from Tamaulipas to Yucatan and extending also into British Honduras. Common names recorded for it are—árbol de la cera, huaucanalá (Veracruz and Oaxaca), chac-lolo (Chiapas) (19). In some areas in Mexico it is very prevalent and forms extensive thickets. The fruits are about 1 6 inch in diameter and a labourer is alleged to be able to collect 25-30 kgms. of " berries " in a day which yield on an average 1½ kgms. of " wax " (19). Mixed with tallow it is commonly used for candles and is sold on the markets in some parts of Mexico. The " wax " is also used medicinally there—being taken internally for jaundice and diarrhoea —and small quantities have been exported (27). The other " wax " yielding species, *Myrica Pringlei* Greenm., has similar " berries " but is considerably smaller—not exceeding 3 to 4 feet in height. It is known to occur in Oaxaca, Puebla and Hidalgo.

Wax myrtles occur in various other Central and South American countries. Where " wax " is prepared by the inhabitants doubt exists in many cases regarding the specific identity of the species of *Myrica* concerned. In the Museum collection at Kew there are samples of typical *Myrica* " wax " from Peru, Ecuador, Colombia and Nicaragua. Doubtless " wax "-yielding species of *Myrica* occur also in some of the neighbouring countries. *Myrica arguta* H.B.K., which has a wide range, is the species exploited in many instances. It occurs on the Cordillera Central in Colombia where it is known as " cera de laurel " or " olivo ", being said (5) to be very abundant in the ravines in the environs of Manizales. " Wax " is prepared from it in Colombia and is employed for candle-making. In the Kew Museum collection there are *Myrica* " wax " candles from Colombia which were forwarded by W. Purdie, one of the early Kew collectors who collected during the period 1843-5. A note accompanies them stating that (at that time) these candles were " sold in all the villages of the mountains at ½ a real or 3d. per pound, which is much cheaper than common tallow." Another specimen from a well known collector of last century is a piece of *Myrica* " wax " or " cera de laurel " from the " Forest of Canelos, Ecuador " and forwarded by R. Spruce in 1863.

Raphia (Raffia Wax).

The raphia palm of Madagascar, *Raphia pedunculata* Beauv., which is the source of the raffia or bass so extensively used in horticulture and fancy work, bears a wax coating on the under surface of the young leaflets. This wax has been collected and its properties investigated, Attention was first drawn to it in 1867 (9) but no further notice of it was taken until about 40 years later when organised experiments on the wax-yielding properties of the palm were made in Madagascar and samples of wax forwarded to European countries for report. A large firm of wax refiners has recently informed the writer that " occasionally supplies of Raffia wax are obtainable ".

The palm is common in parts of Madagascar and favours low-lying humid situations, being often abundant along water courses and in swampy areas. It occurs also in drier habitats and it is stated the quality of fibre obtained is variable and depends upon locality (22) It is possible the quantity of wax obtainable from the leaves may also vary according to situation. In addition to Madagascar the palm occurs in parts of East Africa. A special feature of it is the exceptionally large size of the leaves, the rachis of which may be 50 feet and the leaflets or pinnae 5 to 6 feet in length in well grown specimens. Young leaves which are just about to unfurl are in the best stage for the preparation of raffia and are those selected by the natives who carry out the work. These young leaves are cut and taken to the collectors' villages or temporary camps and the leaflets stripped from the rachis. Women then remove by hand the upper epidermis from each leaflet, these epidermal strips when dried constituting the raffia of commerce. After the epidermis has been removed, the leaflets are cast aside and accumulate in large quantities. It is then that the wax can be collected from them if so desired.

In order to collect the wax, the discarded leaflets are placed on matting or cloth and allowed to dry for several days, sheltered from the wind. Protection from wind is necessary as the wax particles are so light that loss may be caused even by slight breezes. After drying, the wax is easily dislodged by beating and may be gathered up in the form of a fine powder or dust. It is then sifted to remove leaf fragments or other extraneous matter and placed in boiling water. The molten wax floats to the surface and is skimmed off and placed in other receptacles to solidify. The yield of wax is relatively small, that from one experiment being ·75% of the weight of leaves or 17% of the weight of raffia fibre extracted from them (17). When one considers that the annual export of prepared raffia from Madagascar has been between 7000 and 9000 metric tons in recent years (22) and that 10 to 17% of this quantity may be taken as the potential wax yield from the leaves cut, it is apparent what large quantities of wax yearly go to waste adhering to the discarded leaflets.

The solidified raffia wax is yellow to dark brown or chestnut in colour and can be readily powdered. It is hard and brittle and in many respects resembles carnauba wax in physical properties, although differing in composition. It possesses approximately the same melting point and exhibits the same behaviour with various solvents (17).

In connection with early attempts at establishing production of the wax, the following remarks from the " Board of Trade Journal " (Sept. 10, 1908, p. 534) are of interest. " The natives were at the time of discovery induced to prepare about 100 lbs. of this wax which was offered for sale at the market of Maravoay in October 1905. It was sold in small lots at 1/- per lb. Beyond these sample lots no shipments have been made nor has the preparation of wax been continued, the price of 1/- per lb. hitherto offered being considered by the natives insufficient to recompense them for the time and trouble expended on its preparation, a very large number of leaves being required to produce even 1 lb. of wax."

Rhus (Japan " Wax ").

The fruits of certain species of *Rhus* contain a fatty substance, chiefly in the pericarp, which is generally although erroneously referred to as " wax ". The best known of these species is *R. succedanea* Linn., the source of the so-called " Japan wax " of commerce. Other species of *Rhus* occurring in China and Japan also contain a fatty or wax-like material in the fruit and may be exploited for " wax ".

R. succedanea Linn. is a small tree with a wide distribution in Eastern Asia and occurs in the Himalayas, Indo-China, China and Japan. It is in the two last mentioned countries that it is exploited for " wax ". In Japan it exists both wild and cultivated and is stated to be very prevalent in the islands of Shikoku and Kiushiu, particularly in the provinces of Higo, Hizen, Chikugo and Chikuzen. In addition to field culture it is grown along roadsides and on the edges of cultivated fields. Trees are systematically pruned and manured and propagation can be effected either from seeds or basal shoots. Several different varieties or cultivated forms are recognised. It is stated (18) that trees grown from seed do not commence to bear until the fifth to seventh year. The maximum yield is reached in about the fifteenth year when 60 lb. of fruit may be expected or even considerably more is well favoured situations. Subsequently the yield gradually diminishes.

The greenish brown fruits, which are about the size of a pea when dry and contain a single seed, are borne in bunches and ripen in the autumn. If left they remain attached on the tree for quite a considerable period. After collection they are usually sun dried for a few days preparatory to being worked for " wax ". Several methods are employed in extracting the " wax ", the more recent being by the use of solvents. Other methods consist of placing the

ground or bruised fruits in boiling water and separating the molten " wax " that comes to the surface or subjecting the ground fruits to the action of steam and then pressing. By the last mentioned method different qualities of " wax " are obtained, that from the first pressings being the best. In order to obtain the last traces of " wax " from the presses small quantities of perilla oil (*Perilla ocymoides* Linn.) may be added. This causes the resulting product to be somewhat softer and is said to account for the variation in hardness in commercial samples of Japan wax.

This " wax " has been in use in Japan since remote times, being employed chiefly for candle-making and to a lesser degree for polishing purposes. Considerable quantities are now exported, the " wax " being used for a variety of purposes including the manufacture of wax matches, polishes, crayons, special soaps and some of the uses to which other vegetable waxes and beeswax are put. It is also used in laundry work. The melting point (50-54°C.) is appreciably lower than that of most vegetable waxes (13). It usually appears on European markets in cakes, about 6 inches square and 1½ inches thick, creamy white in colour and opaque, sometimes stamped with Japanese characters. If much moisture is present in the " wax " the surface becomes covered in time with a fine pure white crystalline deposit.

Saccharum (Cane Wax).

In the Sugar Cane, *Saccharum officinarum* Linn., a waxy substance occurs freely on the stalks in the form of a white powdery layer. This layer or film varies in thickness on different parts of the stalk and also with different varieties of cane. In some varieties it may be almost absent, in others present to the extent of ·05% (30). Its development is usually most pronounced in the proximity of the nodes.

Wax is very prevalent on the well known variety known as uba which is now widely distributed throughout the warmer countries of the world and has played so important a part in the sugar industry of Natal, largely on account of its general hardiness and high yielding capabilities. The stalks of this variety are thin with long internodes and the heavy wax coating gives to them a peculiar bluish bloom. Where this cane is milled the filter press cake may contain up to 17% of crude wax and 14% is quite common. This percentage is in excess of that in most cane-growing countries. When the cane is burned before cutting—a common method in Natal of removing the trash which is tenacious in this variety and difficult of removal by hand—the quantity of waxy material in the press cake does not exceed 10% (3). There are serious difficulties to be overcome in extracting the wax in a pure state from the press cake, as it occurs there contaminated with fatty and resinous substances.

If the wax is removed by mechanical means from the stalks before milling this contamination does not occur and the wax is

then obtained is a fairly pure state. However, no practically successful method for the mechanical separation of the wax from the stalks has yet been devised, although various attempts have been made. These include brushing the wax from the stalks by machinery before milling or removing it by subjecting the canes to a stream of hot water with provision for subsequent recovery of the wax. Attempts at obtaining the wax from the juice by centrifugalizing have also been made, the cloudiness or turbidity of cane-juice after milling being largely due to the presence of wax particles in suspension. However, it would appear that these methods have not met with lasting success and that at present the only commercial method of obtaining the wax is by the extraction of the filter-press cake with solvents. This is the method that has been adopted in Natal where large scale production of wax has perhaps received more attention than elsewhere. It has been found that the fatty substances present in the filter press cake tend to disappear on prolonged exposure to the air, resulting in a harder crude wax containing a higher percentage of pure wax (23).

Refineries for preparing cane wax were first established in Natal at Durban in 1916, the wax being used locally for industrial purposes, chiefly the making of boot and floor-polish. It was also exported, 250 tons being exported to London during the following two years. Drawbacks have been raised by some polish manufacturers against the extensive use of the wax (as generally received) chiefly on the grounds of colour and difficulty of bleaching, in some instances odour, and the fact that on prolonged contact with moisture it has a tendency to become granular (23). The writer has been informed by a representative of a large firm of polish manufacturers that attempts at using the wax on a large scale by his firm were not satisfactory, one of their chief objections being the offensive odour which permeated the whole factory while it was being worked. However, occasional supplies of cane wax are said to be obtainable in this country.

Chemically purified cane wax is a shining, pale yellow product, resembling refined carnauba wax in many respects. It is hard, readily pulverisable and capable of giving a high polish. Melting point figures given by different workers vary somewhat but are mostly in the neighbourhood of 80°C. (23, 30).

Stipa (Esparto or Fibre Wax).

Esparto grass (*Stipa tenacissima* Linn.) is a raw material obtained from certain Mediterranean countries, chiefly Spain and Northern Africa, which is largely used in the paper-making industry. Wax occurs on the leaves and may be collected as a by-product when the grass is treated for paper manufacture.

Esparto grass (in the dried state) reaches the paper mills in this country in the form of tightly pressed bales. Before the necessary chemical treatment for paper-making is possible these

bales have to be loosened and torn to pieces, a process performed by machinery. During this operation a good deal of dust is liberated which is drawn off in a strong air current and subsequently collected. This dust was formerly regarded as simply a troublesome waste material, but was later shown to contain from 25 to 50% of wax, which may be extracted by various means. Wax occurs also in the alkali liquor in which the grass has been boiled, which, however, is said to be scarcely worth recovering as it is present only in small quantity and the quality is inferior to that obtained from the dust (1).

This wax obtained as a by-product from the esparto paper industry, is now used by polish and other manufacturers in this country and is known by the trade name of fibre wax. The quantity of dust obtainable from any one paper mill is not large and the output of the wax is said to be insufficient to meet the demand. The melting point of the wax has been given as 74°C. (1). A sample recently received at Kew is dark brown to chocolate in colour and very hard and brittle.

Wax is present to a noticeable degree on numerous other grasses, particularly among tropical species and those occurring in arid regions. Among Australian grasses wax is well developed in *Glyceria ramigera* F. Muell., a perennial species known as cane grass or bamboo grass and occurring in some of the inland areas of New South Wales, Victoria and South Australia. This grass and its wax have been described by Smith (26) who states : " It is a coarse cane-like species, has a hard stem and grows in what are known as ' cane swamps '. It has considerable weather-resisting properties and being quite suitable for thatching is employed for that purpose in localities where it grows abundantly.....The entire stem is coated with an almost colourless wax which separates in flakes when the stem is sharply bent. The wax as thus separated melted at 82°C. and in appearance, melting point and hardness, much resembles carnauba wax and might be equally well employed for industrial purposes. It is sufficiently hard and brittle to be powdered, and although but little soluble in ether, yet the ether has the property of separating the wax entirely from the stem, the greater portion falling to the bottom of the containing vessel as a whitish powder." The cut stems or culms were found to yield 2·6% of wax (26).

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LI Notes on an Expedition to the Rupununi District British Guiana: T. A. W. Davis

The material which has formed the basis of recent parts* of Mr. N. Y. Sandwith's current series of " Contributions to the Flora of Tropical America " was collected during a tour of the balata forests, of the Rupununi District. The collection of botanical specimens

* See K.B. 1933, pp. 323-339 ; 1935, pp. 117-132.

was only a secondary objective, and was restricted to some extent to the forest trees, as lack of transport prevented me from carrying sufficient presses to make a more general collection. My work on balata necessitated my spending a considerable part of the time in the heart of the forest, away from the banks of the larger rivers, to which collecting in such regions is usually more or less confined; the ground covered is therefore partly new, though the Schomburgks collected extensively in the district about ninety years ago.

The tour was made between June and November 1931, *i.e.* during the greater part of the rainy season (May to August) and the beginning of the dry season (September to April). June and July were spent partly at Apoteri near the mouth of the Rupununi River, and partly in touring camps of balata bleeders, one excursion being made to King William IV's Fall on the upper Essequibo, and one to the junction of the Kwitaro and Rewa Rivers. Each journey occupied eleven days, and about a dozen camps between one and eight miles from the river banks were visited. Where the camps were near the river I usually had an opportunity of going farther back and seeing the forest in which the men were working. Much of the time in the Essequibo was spent in travelling and I went into the forest only in the hilly country near King William IV's Fall, but in the Rewa the camps visited were well distributed, and were all in the plain to the north of the Kanaku Mountains. Throughout August I was camped on the Simuni Creek about five miles from the foot of the mountains near the western end of the lowland forest region lying between the Kanakus and the Essequibo and Rupununi Rivers. In the upper reaches the Simuni flows through dense forest, lower down through open savanna, but with the forest never far from its eastern bank. The country covered in this part of the district is probably a fair sample of the large tract of forest in the plain between the Pakaraima and Kanaku ranges.

From Simuni I went up the Rupununi into the northern savanna (*i.e.* the area between the Pakaraimas and Kanakus lying to the west of the forest region) with the intention of camping somewhere in the interior of the Kanaku Mountains, but through lack of porters I was unable to carry this out, the only form of transport I could obtain being a light bullock cart. I was fortunate, however, in meeting a rancher who was going up the Rupununi into the mountains to a place a few miles above the Maparri Creek, and spent two days there with him. About the middle of September I crossed the savanna to Bon Success on the Takutu where I made my headquarters, and went into camp for a fortnight at the edge of the forest which skirts the base of the mountains. Here my work was confined to the base and northern slopes of the range near Mts. Iramaikpang and Nappi.

My last journey in the district took me into the savanna to the south of the Kanakus, where I spent five days on Mt. Kusad, an isolated forest-clad range some ten to twenty square miles in area

situated about the middle of the savanna, and a week on the Kanakus near Sand Creek Village on the eastern side of the Rupununi. The northern slopes of the Kanaku Mountains are everywhere wooded and the forest extends for a mile or so into the plain at their foot, The southern slopes however, are only partly clothed in forest which seldom encroaches into the plain, and in many places the savanna ascends to the tops of the outer ridges ; patches of it occur even on the hills and in the valleys immediately beyond them. The Indians require forest land in which to grow their cassava (*Manihot utilissima*) and other provisions, so that whereas the Makushis living near the northern foot of the mountains can make their clearings in the forest at their base, the Wapisianas of the southern savanna have to ascend to the upper valleys to find a ground suitable for cultivation. The paths to their fields are usually good enough for pack bullocks to be used, and horses can be ridden over them except on the steepest gradients. Often there are houses near the fields in which the Indians stay while making new clearings, the distances being too far from their permanent houses. As a result food and shelter for a short period can be obtained in certain places on the mountains, which more than half solves the transport problem, and enabled me to reach localities more remote than I found possible on the northern side.

The forests covering the plain between the Essequibo and the northern savanna are of a definite and remarkably uniform mixed type. They are decidedly drier than the mixed forests of the North-West District or the Greenheart (*Ocotea Rodioei* (Schomb.) Mez), Morabukea (*Mora Gonggrijpii* (Kleinh.) Sandwith) and mixed forests of the central part of the Colony, and are intermediate in character between evergreen tropical rain and monsoon forest. The difference shows itself in the greater number of predominant trees, and of deciduous species, the slightly more open and irregular canopy, and the rather less luxuriant undergrowth. The average size of the leaves of the trees which form the upper layers of the canopy is decidedly smaller than in the true rain forests, and the mimosaceous type of leaf is commoner. The average height of the canopy is between 100 and 120 feet, and the outstanding trees are up to 150 feet high. Large areas along the rivers are flooded to a considerable depth annually during the rainy season, but in the dry season they have a low water table. These are normally covered with a somewhat dense growth of small trees which form a close canopy with a greatest height of thirty or forty feet. Above this canopy the large branchy rather flat-topped crowns of scattered trees of considerable girth but no great height rise at intervals. There is usually little or no herbaceous ground-cover in such localities. The more permanent swamps support a type of vegetation in which palms, principally *Maximiliana regia* Mart. (kokerite) and lu (possibly an *Oenocarpus*) are dominant, or in wetter places *Euterpe* sp. (manicole). Open forest of rather small-stemmed trees with a

closed ground-cover of tall coarse grasses is another common type on swampy ground.

The floristic composition of these forests is markedly different from that of the true rain forests nearer the coast. The association has as its dominants *Mimusops Balata* (Aubl.) Gaertn., *Swartzia* sp. (? *S. leiocalycina* Benth.), (wamara), and locally *Aspidosperma excelsum* Benth., (yaruru), which is here sometimes gregarious. The principle families are more or less the same in both types, but in the *Mimusops-Swartzia* association the *Leguminosae* and *Sapotaceae* are everywhere dominant, and the *Rosaceae* and *Lecythidaceae*, though probably next in importance, are less abundant than in the rain-forest, and in the case of the latter the genus *Couratari* is probably represented by as many or more individuals than *Eschweilera*. In the lower layers of the canopy the *Annonaceae* are represented by a great number of species, but *Tapura guianensis* Aubl., (waiaballi), is actually the dominant species. *Bertholletia excelsa* H.B.K., (Brazil-nut), occurs locally in the Kwitaro and Rewa rivers, and two small areas of greenheart (*Ocotea Rodioei* (Schomb). Mez) forest were found in Simuni Creek. Mora (*Mora excelsa* Benth.) forest is of common occurrence in suitable localities, and covers considerable areas along the streams near the base of the mountains. It is similar to the Mora forests of other parts of the Colony, though its associates are naturally the species belonging to this district.

The forests of the Kanaku Mountains appear to vary considerably from place to place especially in their flora, but my examination of these was too sketchy for my observations to be of much value. Generally speaking they are similar in character to the *Mimusops-Swartzia* type, but rather more mixed, and if the localities I visited are typical the dominants are not the same. On the south side of the Kanakus there is a marked tendency for a single species such as *Peltogyne* spp. and *Mimusops excelsa* Ducke, (iwakush), to become locally the sole dominant, especially on rather dry rocky slopes. On the slopes near the rivers the sand kokerite palm (? *Attalea* sp.) was found to be dominant on the northern side of the Kanakus both on the Rupununi River and in one locality on the Essequibo. It is probable that the forests of the remoter valleys are more uniform in character.

The transition from forest to savanna is marked by the presence of patches of savanna in the forest, but the actual line of division is abrupt. I saw one such patch not more than two acres in extent as far east as Apoteri, and on the left bank of the Rewa they are said to occur fairly frequently and occupy considerable areas. The savanna is mainly open grassland, the higher ground being covered almost exclusively by a single species, whilst the low-lying areas subject to inundation have a more mixed vegetation of sedges, grasses, and many dicotyledonous herbs. The grassland is interspersed in places with low bushy trees and shrubs, which form patches or belts with the trees widely spaced, and in some places orchard-like groves which

occasionally form a partly closed canopy. The dominant species is *Curatella americana* L., (sand-paper bush), and other abundant species are *Bowdichia virgilioides* H.B.K., (mach), *Antonia ovata* Pohl var. *pilosa* (Hook.) Prog., (inyak), *Byrsonima crassifolia* (L.) H.B.K., (idin), a *Plumeria*, a *Psidium*, and *Acacia polyphylla* DC., (parika), the last usually growing only near the edge of patches of forest which occur here and there in the savanna, and are locally termed islands. The small areas of forest on the higher ground have a distinct flora of their own, which, however, includes many species which occur in the neighbouring forest areas. Among the most characteristic species are *Centrolobium paraense* Tul., (kartang), *Cordia trichotoma* (Vell.) Arab. and *Lucuma sericea* Krause. The canopy is between 60 and 80 feet high, and the undergrowth dense, shrubby, and with little foliage. The islands I visited are probably all of secondary origin. Along many of the streams where the banks are low there is a fringe of *Mauritia* palms, which sometimes form patches of closed forest in low-lying areas ; where the banks are higher there may be a narrow fringe of bushes and low trees, among which are *Eschweilera Schomburgkii* (Berg) Ndz., *Licania coriacea* Benth., *Licania* sp., and *Swartzia dipetala* Willd. ex Vogel, or occasionally they may be bordered by open grassland.

The flora of the Rupununi District is akin to that of the adjacent districts of Brazil. The savannas are identical with those which occupy a large tract of country round the Rio Branco, of which they are in fact the eastern extremity. In the forest areas the flora differs more than would be expected from that of the Guiana rain forest to the north-east of them, the difference being greater than can be explained by a slightly lower rainfall. From what little we know of it, it appears to be more closely allied to the Amazonian flora. The inference is that the forests of the Kanaku Mountains and the plain along their northern base are pre-climaxes of the Amazon rather than the Guiana rain-forest, which is characterised by so many important endemic species only a very few of which extend into the forest of this district.

LII—MISCELLANEOUS NOTES.

H. R. Briton-Jones.—We regret to record the death of Professor H. R. Briton-Jones, Ph.D., D.Sc., which took place in Trinidad after an operation for appendicitis, at the early age of 43.

Harry Richard Briton-Jones was a student at the Royal College of Science in 1914, and at the outbreak of war had just gained the A.R.C.S. and had started on post-graduate work. He returned to the College in January 1918, having served with distinction in the R.G.A. In the autumn of 1919 he came to Kew for a course in tropical mycology preparatory to taking up the post of Mycologist to the Ministry of Agriculture, Egypt. After three years in Egypt he returned to England as Mycologist at the Horticultural Research

Station, Long Ashton, and from there he proceeded in 1926 to Trinidad as Professor of Mycology at the Imperial College of Tropical Agriculture.

Briton-Jones was essentially a plant pathologist rather than a mycologist, and his work throughout is characterised by its grip of the practical and economic side. In Egypt his most important piece of work was concerned with the disease known as "sore shin" of cotton, an account of which is given in Bulletin 49 of the Ministry of Agriculture, Egypt ("Mycological Work in Egypt during the period 1920-1922"). At Long Ashton his attention was naturally turned to diseases of fruit trees, and he developed the standpoint that the health of the host plant is usually the primary factor determining whether the attack of parasitic organisms shall succeed. It was the importance of this aspect of approach to his subject which led to his study of horticulture, and before leaving for Trinidad he took his D.Sc. in that subject at the London University. This viewpoint came out more strongly in connexion with his observations on root-diseases in the West Indies, and is again emphasized in his book, "The Diseases and Curing of Cacao," published in 1934 (see review in K.B. 1935, 161-162).

As a pupil and as a colleague Briton-Jones was very much liked, though his impulsive Celtic temperament sometimes brought him into opposition, temporarily, with more cautious individuals.

As Dean of the College for the past nine years he rendered valuable service and was very popular with the students year by year. Being a keen Rugby Football player, a good sportsman, and a gentleman in every sense of the term, he occupied a position of confidence and responsibility among the students in the College which it will be difficult to fill. His untimely death is a great sorrow to his many friends.

Cedric Errol Carr.—Mr. Carr was the only son of the late John Thomas Carr, C.E., and was born at Napier, New Zealand, on November 16, 1892. At the age of 7 he went with his parents to England and was educated at Dulwich College. He came to Malaya in January 1913 as an assistant on Kulong Rubber Estate, Malacca, but returned to England in 1916 for military service, and was wounded severely at Arras in July 1917 and again in August 1918. He returned to Malaya in 1919, becoming manager of Lendu Estate, Malacca, and then of Tembeling Estate, Pahang, until 1931.

From his boyhood Carr took a great interest in British orchids. When he went East he began to study the orchids of Malaya, and soon became familiar with the species of the Malaccan countryside, but it was not until he went to Pahang that he began the intensive study which continued to his death. The isolation of Tembeling, in the midst of some of the richest forest in Malaya, brought Carr into more intimate contact with tropical nature, and he was overwhelmed by the richness and variety of the orchid flora. He took frequent

expeditions into the surrounding country and brought plants alive to his garden at Tembeling, where he watched them flower. He collected and grew in this way some 400 local species. He early made a careful study of pollination and other aspects of floral biology, which was embodied in a paper published in the " Journal of the Malayan Branch, Royal Asiatic Society," in 1928. The writing of this paper brought Carr into contact with the staff of the Botanic Gardens, Singapore, and for the next few years visits were interchanged, to our mutual advantage. Carr made full use of the Gardens, library and herbarium, and Tembeling became a centre for botanical expeditions, which greatly enriched our knowledge of the Malayan flora. Carr's own collections added somewhere about 100 species to the known orchid flora of the Peninsula. He was particularly interested in small plants, and of the genus *Taeniophyllum* added thirteen species to the four previously known. His papers, in which the new species are described, were published in the " Gardens Bulletin S.S."

After leaving Tembeling, Carr undertook an expedition to Mount Kinabalu in British North Borneo, where (in addition to a great variety of other plants) he collected some 700 species of orchids, a large proportion of which he considered to be new. Unfortunately he did not live to complete the description of these collections. He went to England in 1933 and worked for a time in the Kew herbarium, leaving at the end of 1934 for his Papuan expedition, which was in sight of successful completion when he fell ill with blackwater fever. He was conveyed 100 miles by aeroplane to Port Moresby, where he died in hospital on June 3, 1936. The Papuan expedition covered a considerable variety of country concluding with seven months on Mount Victoria, and the serial numbers of collections reached a total of about 7,000.

Thus the botanical world has lost in his prime a man who gave promise of becoming one of the leading orchid systematists, and a field worker of outstanding ability. Indeed, it was in the field that one got the true measure of Carr as a naturalist, and felt something of the absorbing passion he had for his work.

R. E. HOLTTUM.

Hydnocarpus Wightianus in Nigeria. In the article by Mr. J. D. Kennedy on this subject in K.B. no. 6, 1936, it was stated (p. 344) that the report on a sample of seed sent to the Imperial Institute for analysis had not yet been received. Since this was written the report has been made and published in the " Bulletin of the Imperial Institute," **34**, no. 2, pp. 146-151 (1936).

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